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RESEARCH ARTICLE

Development of DSP Based Scanning Probe Control Using Open Source Software Package GXSM

J.S. Devrenjith Singh[1], Alfred Kirubai Raj[2], S.K. Suresh Babu[1], D. Devaprakasam[3]*

[1]Department of NanoTechnology, Karunya University, Coimbatore-641114, India.
[2]Department Electronics and Communications, University, Coimbatore-641114, India.
[3]School of Mechanical and Building Sciences. VIT University, Chennai Campus, Chennai, 600127

ABSTRACT: Gnome X Scanning Microscopy (GXSM) is a full featured and modern scanning probe microscopy (SPM) software. It can be used for powerful multidimensional image/data processing, analysis, and visualization. We connected to an SPM instrument and found that it can operate and control different configurations of SPM, e.g., scanning tunneling microscopy (STM) and atomic force microscopy (AFM) or in general two-dimensional multi-channel data acquisition instruments. The GXSM core can handle different data types, e.g., integer and floating point numbers. An easily extendable plug-in architecture provides many image analysis and manipulation functions. A digital signal processor (DSP) subsystem runs the feedback loop, generates the scanning signals and acquires the data during SPM measurements. The programmable GXSM vector probe engine performs virtually any thinkable spectroscopy and manipulation task, such as scanning tunneling spectroscopy (STS) or tip formation. The GXSM software is released under the GNU general public license (GPL) and can be obtained via the Internet. In this project the front end is implemented in Linux operating system and connected to the data acquisition device with the kernel module and the data were been acquired using the unidata NetCDF. The SR-Hwl plugin are used to run the device in no hardware mode. The data acquisition tool consists of DSP&FGPA in which is X, Y, Z offset are connected to the Piezo drive.

Key Words —GXSM, STS, DSP, FGPA, SPM, SR-Hwl

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I. INTRODUCTION

Gnome X Scanning Microscopy (GXSM) is a powerful graphical interface for any kind of 2D and 3D (multilayered 2D mode) data acquisition methods, especially designed for scanning probe microscopy (SPM). GXSM provides various methods for 2D data (of various types: byte, short, long, double) visualization and manipulation. We are currently using it for scanning tunneling microscopy (STM), atomic force microscopy (AFM), scanning angle resolved light scattering (SARLS), and spot profile analysis of low-energy electron diffraction (SPA-LEED). The program was developed for Linux using the Gtk+/Gnome libraries for the graphical interface. Support for STM, AFM, SPA-LEED, SARLS, and any other 2D (2D layered and multi- channel) data-acquisition method can be supported by GXSM [1]. The GXSM core handles multiple channels of 2D (layered) data fields of arbitrary type and unlimited size and a grey-scale or false color view of 2D data image. Data presentation is by default a (grey or false color) image but it can be switched to a profile view (1d), profile extraction on the fly. Or you can use a 3D shaded view (using MesaGL) which now offers a sophisticated scene setup. The "high-level" scan controller is now separated from the GXSM core and is built as Plugin, while the real-time "low-level" scanning process, data-acquisition and feedback loop (if needed), runs on the DSP if present, else a dummy image is produced.

It has extremely flexible configuration of user settings and data acquisition and probe modes. Special instrument control Plug-Ins. A Plug-in categorizing mechanism automatically only load the required Plug-Ins for the actual setup: E.g. no Hardware Control Plug-ins is loaded in "offline" Data Analysis Mode. There are more than 80 Plug-ins used. GXSM itself is fully hardware independent. It provides a generic hardware-interface (HwI) plugin infrastructure to attach any kind of hardware. The HwI has to manage low level tasks and pass the data to the GXSM core, plus, it has to provide the necessary GUI to provide user access and control to hardware/instrument specific parameters and tasks.

The GXSM software can be divided into three parts: First, the GXSM core providing the main functionality for handling and visualization of data. . The basic functions of the GXSM core can be extended using plug-ins. Plug-ins are small pieces of software dynamically linked to the core. The plug-ins is described in the second part of the manual. The third part documents the digital signal processing (DSP) software needed to carry out actual measurements. The DSP software is not necessary for applications using GXSM only for data analysis purposes.

II. HARDWARE USED

A. Signal Ranger MK2-A810

The Signal Ranger Mark2 DSP with the A810 analog board is powered by the TMS320C5502 running at 300 MHz and uses a high speed USB-2.0 interface for all communications with the host PC and GXSM. The SPM Open Source Controller model used is Mk2-A810. This DSP-based system has been specially designed to meet the Scanning Probe Microscopy (SPM) application requirements.

Advanced SPM features can be implemented using the 16 individually configurable GPIOs and the two16-bit counters. These counters are synchronized with the analog sampling

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****Corresponding Author:*** *devaprakasam.d@vit.ac.in*

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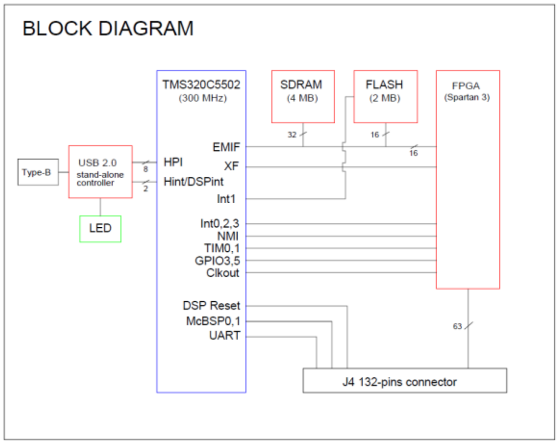
and can be used as simple pulse counters or Quadrature Encoder Pulse (QEP) counters. Based on the SR-MK2 DSP board and SR2-A810 board, the SPM Open Source Controller is a convenient rack-mount enclosure providing quality connectors and wiring to ensure the best S/N ratio. With all these features the kit SR2-A810 + SR-Mk2 has the best performance/price ratio on the market for a SPM control system.

Figure 1 Block Diagram Signal Ranger mk2 DSP board



1. USB

USB 2.0 PC connection has average data throughput: 18Mb/s (reads), 22Mb/s (writes). Stand-alone USB controller requires no management from the DSP software.

2. DSP

TMS320C5502 16-bits fixed point DSP, running at300 MHz, with 32Kwords of on-chip RAM.

3. FPGA

XC3S400 FPGA has 400 000 gates, 56 Kbits distributed RAM, 288 Kbits block RAM,16 dedicated 18x18 multipliers, 4 DCMs. Provides 63 user-configurable I/Os.

4. Power supply

Signal Ranger_mk2 is Self-Powered using an external 5V (+-5%) power pack. It can work without any connection to a PC.

5. Memory

- 64 Kbytes on-chip (DSP) double-access RAM, mapped in data and program spaces.
- 4 Mbytes external 75MHz Synchronous Dynamic RAM, mapped in data and program space.
- 2 Mbytes external Flash Rom, mapped in data and program space.

B. Piezo Control Systems Design

The piezo amplifier, NV 40/3 CLE, was designed for low voltage piezo elements with external measurement systems. The NV 40/3 CLE includes a voltage amplifier, closed loop control, and a display with a PC-interface. The high-resolution display shows the position of the actuator, along with some other information such as: the mode of operation and the temperature inside the amplifier. This piezo amplifier also provides the opportunity to operate the piezo element via an analog modulation input. The position of the actuator can be examined via the monitor output. Due to the very low voltage noise of the output current, only 0.3mV RMS, this amplifier system is ideally suited for positioning applications with sub-nm resolution. Special protective circuits prevent voltage spikes when switching the unit on and off and consequently avert any overload caused by overheating or short-circuiting. The new soft start ensures an actuator-safe activation of the system. With the electronic PID controller this system operates without any drift or hysteresis. Due to its design, and compact casing, the new amplifier is recommended for all R&D and engineering applications.

III. GXSM PROJECT INSTALLATION

A. System requirements

GXSM needs a reasonable up-to-date machine running a recent version of almost any Linux Variant. The recommended OS is the Debian based Ubuntu. System memory requirements are ranging from little to several Gigabytes. To compile and run GXSM the full Gtk+/Gnome libraries, development packages and some additional libraries (FFTW, NetCDF, libQuicktime) are required, but all are available as pack- ages for Debian and Ubuntu. The GXSM is built on Linux OS such as Debian, Ubuntu, Fedora, RedHat, Suse and Mandrake. The recent Ubuntu is the GXSM reference system and is used for development. For more Linux- Distribution dependent installation guides and hints please refer to the online

“GXSM Installation Knowledge” forum:

http://sourceforge.net/p/gxsm/discussion/297458.

B. Compiling and installing GXSM

Change into the Gxsm-2.0 directory in the terminal (ctrl+alt+t). The following steps for compiling Gxsm 2.0 and Sranger.

Configure, Compile, and Install Gsxm-2.0

```
$ cd
$ cd Gxsm-2.0
$ ./autogen.sh
$ make
$ sudo make install
```

Configure, Compile, and Install Sranger

```
$ cd
$ cd SRanger
$ ./autogen.sh
$ make -i
$ sudo make -i install
```

Then install the kernel module for MK2-A810

```
$ cd modules-mk2-2.6.x$ make -C /usr/src/linux-headers-2.6.35-25-generic/ SUBDIRS=$PWD modules
$ sudo check install make -C /usr/src/linux-headers-2.6.35-25-generic/
SUBDIRS=$PWD modules install
$ sudo depmod -a
$ sudo modprobe usb-sranger_mk2
```

Then I open “/lib/udev/rules.d/50-udev-default.rules” and added the following comment at the end of file:

```
KERNEL=="sranger_mk2_" MODE="0666".
```

Programming DSP and FPGA

From a Windows machine, start SR3_MiniDebugger.exe. Use SR2_NG in the pull-down menu for the SR2 "New Generation" The two files required are:

1. DSP File: FB_spmcontrol.out (found at /home/fimadmin/SRanger/TiCC-project-files/MK2A810_FB_spmcontrol)

2. FPGA File: SR2_Analog_810_V200.rbt (found at /home/fimadmin/SRanger/TiCC-project-files/MK2A810_FB_spmcontrol/SR2_PrepareFlashForSR2_Analog_810)
The SR firmware tools (includes SR3_MiniDebugger.exe) can be found at
http://www.softdb.com/dsp-products-SR-MK2.php
and at the section on SR2_NG
http://www.softdb.com/SignalRangerMk2/SR3_Applications_Installer_V133.exe
If GXSM does not work
To activate the hardware

```
$ cd ~/SRanger/TiCC-project-files/MK2-A810_FB_spmcontrol/python_scripts
$ ./mk2_spm_control.py
```

Then

```
$ gxsm2 --force-configure
```

Specify the correct hardware type, "SRangerMK2:SPM" and the device file "/dev/sranger_mk2_0".

IV. SRANGER CONNECTIONS

Make sure the MK2-A810's flash is up-to date with the latest DSP code for GXSM and (FPGA) logic matching the Gxsm version. The best way to do this is to chec CVS modules Gxsm-2.0 (Gxsm project) and SRanger modules from Srangerproject.

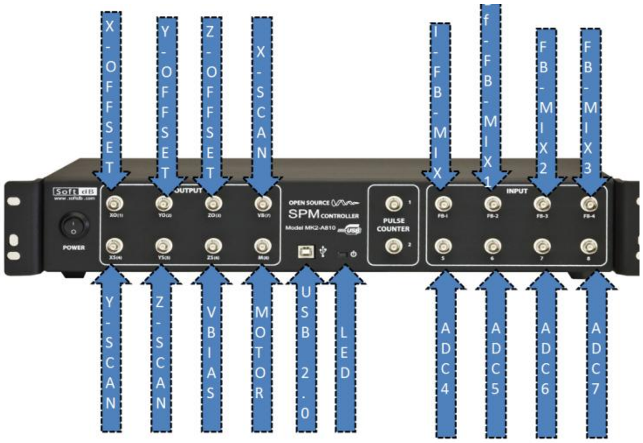


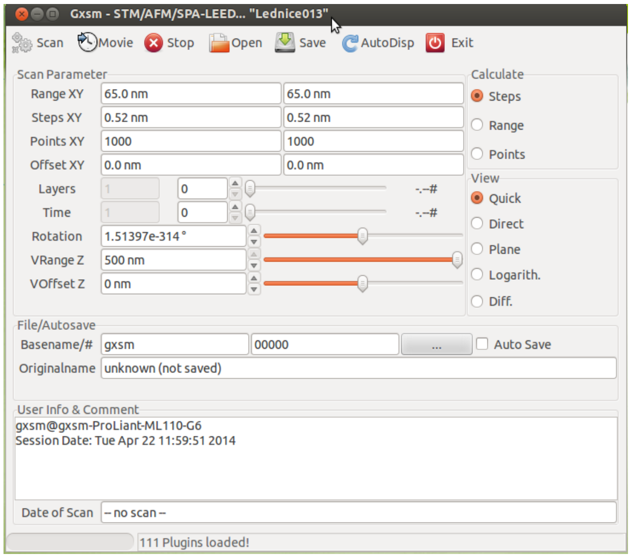
Figure 2 Sranger Connections

V. RESULT AND DISCUSTION

A. The main window

The main window provides two different functions: Firstly, it has a menu bar with pull down menus. These menus provide the user with the usual File and Help menus which can be found in practically every mouse-driven software piece. Some of these pull-down menus interact with (Math) or start-up (Windows) other windows. Secondly, the main menu contains a large number of control fields which can be used, e.g., to control an instrument, or just display certain parameters. These control fields are described in the following two sections.

In the main window we can do the changes to the controller option by using the preference tab. All the main changes are being made in this tab.


Gxsm - STM/AFM/SPA-LEED... "Lednice013"

Scan Parameter
Range XY 65.0 nm 65.0 nm
Steps XY 0.52 nm 0.52 nm
Points XY 1000 1000
Offset XY 0.0 nm 0.0 nm
Layers 1 0
Time 1 0
Rotation 1.51397e-314°
VRange Z 500 nm
VOffset Z 0 nm

Calculate
● Steps
○ Range
○ Points

View
● Quick
○ Direct
○ Plane
○ Logarith.
○ Diff.

File/Autosave
Basename/# gxsm 00000
☐ Auto Save
Originalname unknown (not saved)

User Info & Comment
gxsm@gxsm-ProLiant-ML110-G6
Session Date: Tue Apr 22 11:59:51 2014

Date of Scan -- no scan --

111 Plugins loaded!

Figure 3 shows the Main window

B. SPM CONNECTION PREVEIW MODE

The SPM connection preview mode is given that SPM controller is connected and the right corner of window shows the offset of X, Y, Z in the Piezo drive. The channel selector will allow to select the require topography to be scanned whether 1D, 2D or3D need to be scanned. The scan button will start the can and data's are saved as .nc (NetCDF) extension in the home directory.

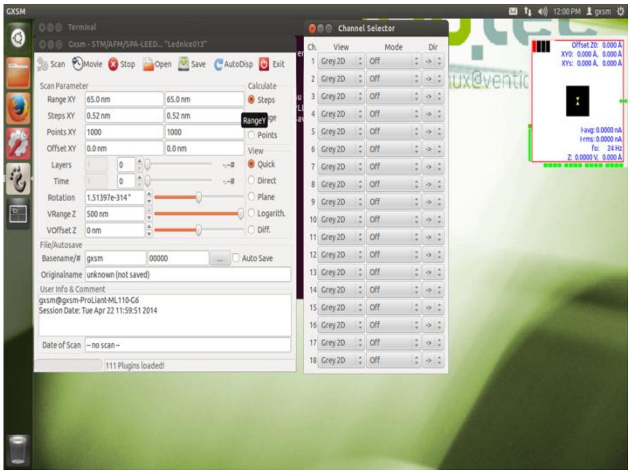


Figure 4 SPM connection preview

VI. CONCLUSION

In this work we successfully developed DSP based SPM control system using open source GXSM software. We implemented nanopositioning by connecting the GXSM user system to the DSP controller system. And configured the Linux based OS to GXSM user interface and controlling window. The outputs of the signal ranger controlling window were verified with the installed Kernel.

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REFERENCE

[1] P. Zahl, M., Bierkandt, S., Schr¨oder., A. Klust. 2003. Rev.Sci. Inst. 74, 1222.

[2] P. Zahl, T. Wagner, R. Möller and A. Klust, "Open source scanning probe microscopy control software package Gxsm", 2010. J. Vac. Sci. Technol. B 28.

[3] P. Zahl and A. Klust, gxsm Software Project Homepage:URL: http://gxsm.sourceforge.net.

[4] P. Zahl, A. Klust, and S. Schr¨oder, The Gxsm Manual,Institut fr Festk¨orperphysik, Hannover, Germany; Colorado School of Mines, Golden, CO, USA; Universityof Washington, Seattle, WA, USA (2002), Online available here: URL: http://gxsm.sourceforge.net, section Manual/Help.

[5] SoftdB, manufacturer of all the Signal Ranger DSP Boards, URL: http://www.softdb.com.

[6] MK2-A810: Signal Ranger MK2 with Analog810 Module, URL: http://www.softdb.com/a-dsp_SPM_Controller.html.

[7] Gxsm Life CD/DVD Ubuntu System can be downloaded here: URL: http://www.ventiotec.com/linux/

[8] GXSM-Linux.iso, provided via Ventiotec Dolega Wagner GbR, Marler Straße 100-102, 45896 Gelsenkirchen, Germany.

[9] Unidata, NetCDF Homepage: is given in the URL: http://www. unidata.ucar.edu/packages/netcdf.

[10] Python scripting language: http://www.python.org.

[11] Piezodrive by Ing. B¨uro W. Reimann, Germany. Go to URL: http://gxsm.sourceforge.net and look at the section hardware for details.